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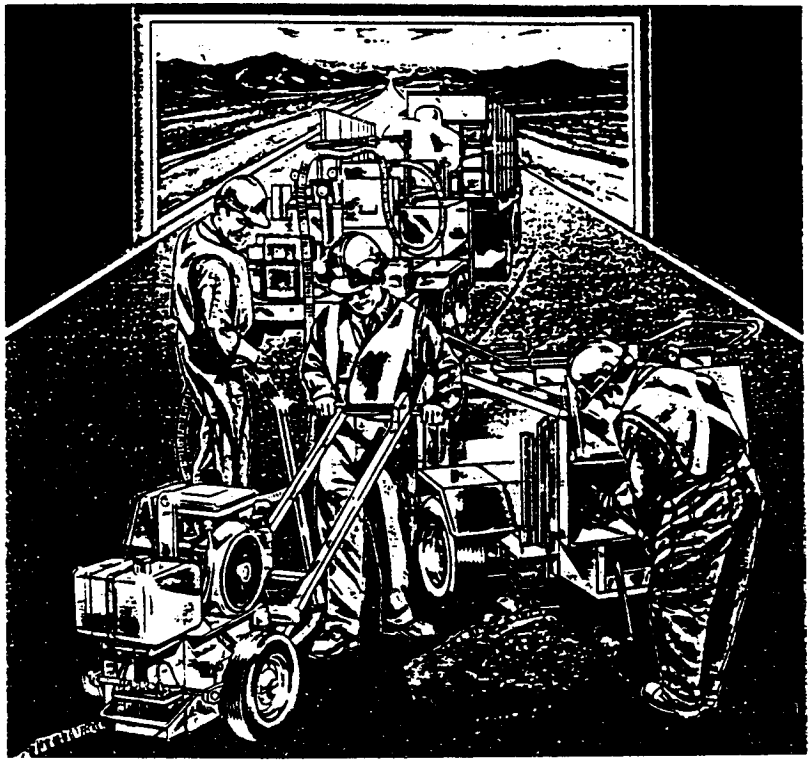
NAVFAC MO-102.8

ASPHALT PAVEMENT MAINTENANCE AND REPAIR



FIELD MANUAL

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PREFACE

This field manual contains information on materials, equipment, and procedures for repairing Asphalt Concrete (AC) pavements. The REFERENCES section contains additional literature information.

ACKNOWLEDGMENT

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REFERENCES

1) NAVFAC MO-102 “Maintenance and Repair of Surfaced Areas”
2) NAVY DM 21.3 “Flexible Pavement Design for Airfields” Aug 78
3) Dept. of the Army and Air Force TM 5-822, AFM-88-6 Chapter 9 , “Bituminous Pavements Standard Practice”
4) Department of the Navy, NAVFAC DM-5.4, “Civil Engineering-Pavements”
5) NAVFAC NFGS-02788A “Coal Tar Seal Coat with Unvulcanized Rubber”, Mar 96
6) NAVFAC NFGS-02789A, “Bituminous Surface Treatment” Mar 96
7) NAVFAC NFGS-02744A “Bituminous Tack Coat” Mar 96
8) NAVFAC NFGS-02743A “Bituminous Prime Coat” Mar 96
9) NAVFAC NFGS-02785A “Bituminous Sealcoat, Spray Application” Mar 96
10) NAVFAC NFGS-02786 “Fog Seal”, Mar 96
11) NAVFAC NFGS-02787A “Asphalt Slurry Seal” Mar 96
12) NAVFAC NFGS-02742A “Bituminous Hot Mix Pavement” Mar 96
13) AF Engineering and Services Center Special Study, “Maintenance of Porous Friction Surfaces” June 1980
14) Asphalt Institute Publication - MS- 4 “The Asphalt Handbook”
15) US Army Corps of Engineers Cold Regions Research and Engineering Laboratory Publication “The Engineers Pothole Repair Guide” No. 84-1

TABLE OF CONTENTS

Each Section Covers Materials, Procedures, and Problem Areas

PURPOSE OF BITUMINOUS PAVEMENT MAINTENANCE AND REPAIR (M & R)

The purpose of maintenance and repair (M & R) of asphalt pavements is to:

A. Extend the useful life of the pavement
B. Maintain a smooth riding surface
C. Prevent water from entering the underlying pavement structure

M&R has become increasingly important to the pavement life because of limited manpower and resources. To keep the pavement in the best possible condition, it is important to have and use an effective pavement management and inspection system. When doing repairs, it is extremely important to fix the **TRUE CAUSE** of the pavement distress, not just the distress itself. For pavements to function as intended, you must do **PROPER** and **TIMELY** maintenance and repair.

To implement an effective pavement management and inspection program, use NAVFAC MO-102.5 "Pavement Maintenance Management" which describes the procedures to be used for pavement condition surveys (for airfields, roads and parking lots). They include descriptions of all AC pavement distresses and severity levels. The use of the computer program “PAVER/GIS” developed for the U.S. Army Construction Engineering Research Laboratories (USACERL) by Dr. M. Y. Shahin is highly recommended in developing a pavement management program.

TYPES OF M & R

There are many different types of M & R methods for AC pavement that range from crack sealing, sealcoats to complete AC overlays. This manual will cover the basic M & R procedures and distresses they repair. Crack sealing is covered in the Asphalt Crack Repair Manual NAVFAC M0-102.6.
The procedures to be discussed in this manual are:

A. Patching:

1. Full-Depth Patch: Used to repair high severity alligator cracking, corrugation, depression, oil spillage, rutting, swelling, bumps and sags, replace patches, and potholes.

2. Partial-Depth Patch: Used to repair low to medium severity alligator cracking, bumps and sags, edge cracking, joint reflection, potholes, railroad crossing, shoving, and slippage cracks.

3. Utility Cut Repair: Used to repair the pavement surface depressions within utility cut areas resulting usually from improper compaction of any or all of the layers of the replaced section.

4. Filling Depression and Ruts: Used to repair low spot areas to restore the area to the same grade as the surrounding pavement.

B. <u>Asphalt Surface Treatment</u>: There are several types of asphalt surface treatment that range from single, light application of diluted emulsified asphalt to multiple surface courses made up of alternate application of asphalt and aggregate. Each type of asphalt treatment is for one or more specific purposes. It is important that a careful study of traffic requirements, along with an evaluation of the condition of existing materials and pavement layers, be made prior to deciding which surface treatment to use.
The different types of asphalt application for use are:

1. Sprayed Asphalt Surface Treatment: These are **fog seals**, **prime coat**, and **tack coat**. The following describes their primary functions. Fog seal is used as a repair alternative for repairing small cracks (less than 1/4 inch), or for pavements that have become weathered, oxidized, or brittle. Prime coat is used to promote adhesion between the base course and the asphalt course to be placed over it. Tack coat is used to provide a bond between new and existing pavement.

2. Sprayed Asphalt and Aggregate Surface Treatment: These are single surface, multiple surface treatments, and sand seal. The first two are commonly referred to as chip seals. Chip seals renew surfaces and restore skid resistance to traffic-worn pavements. Sand seal also improves the skid resistance of slippery pavements and seals the surface against air and water infiltration.

3. Asphalt Slurry Seal: Is a mixture of well-graded fine aggregate, mineral filler, emulsified asphalt, and water. It is used in both the preventive and corrective maintenance of asphalt pavement surfaces. It seals surface cracks, stops raveling, improves skid resistance and pavement appearance. Slurry seal is **not allowed** as surface treatment in airfields with a high volume of tactical jets due to possible foreign object damage (FOD). See page 45 for limitations to and the special requirement for the use of slurry seals on airfield asphalt pavements.

4. Fuel-Resistant Sealers: Used to protect asphalt pavements (parking lots, airfield apron, fueling sites) subject to fuel spillage, oils, and hydraulic fluids that soften the asphalt binder causing the asphalt to erode and disintegrate. Commercial fuel sealers are available today, including various epoxy rubber compounds. They may be applied mechanically, or by hand as slurry mixture in one or more coats. These sealers are coal tar emulsions with rubber, a coal tar with epoxy, a resin epoxy, a rubberized sealant, and a rubberized adhesive. Sand may also be added for skid resistance.

C. Asphalt Concrete (AC) Overlay: Used to correct both surface deficiencies (raveling, roughness, slipperiness) and structural deficiencies. One or several courses of asphalt concrete mix are placed and compacted over an existing pavement.

There are often several different methods for repairing the same type of pavement distress. When choosing a repair method look for the **TRUE CAUSE** of the distress and choose the method that will best resolve that cause. All of the procedures are presented using the logical steps to accomplish the tasks (e.g., 1, 2, 3,.....)

PATCH PROCEDURES FOR
FULL DEPTH, PARTIAL DEPTH, UTILITY CUT REPAIR, FILLING DEPRESSIONS & RUTS

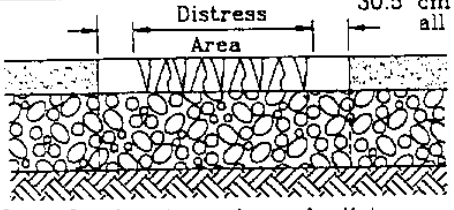
STEPS

1. Mark the Repair Area. Use a string line or straight edge. Make the marks with a spray paint so they are easy to see when sawing. Mark the area to form a square or rectangle: (a) at least 12 inches beyond the distressed area for full depth and partial depth repairs **(Figures I & II)**, see pages 9 & 10; (b) at least 6 inches beyond the distress area for utility cut repair **(Figure III)**, see pages 11 12; and (c) at the location where the edges of the depression or rut are at the normal surface levels **(Figure IV)**, see page 13.

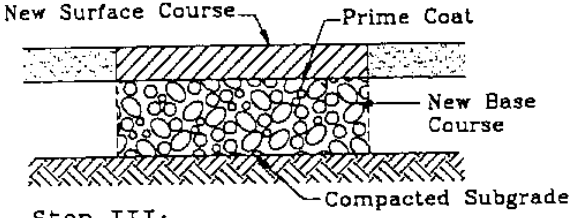
2. Sawcut the Repair. For full depth, partial depth, and utility cut repairs, use a concrete saw with a diamond tip or abrasive blade **(PHOTO 1)** see page 14. Make sure the saw cuts overlap so that you have a vertical, square corner **(PHOTO 2)** see page 14. Diamond tip blades usually require water, so ensure the area is completely dry before it's repaired. There are some types of diamond tip blades designed to dry cut asphalt. The abrasive blade has the advantage of lower cost, and doesn't use water. The disadvantage is that it tends to wear out quickly. Make sure that the blade is large enough to cut the full depth of the pavement and is the correct Revolution Per Minute (RPM) rating for the saw. If the blade is not the correct RPM rating it could shatter during sawing.

FULL-DEPTH REPAIR
(Figure I)

Method 1:

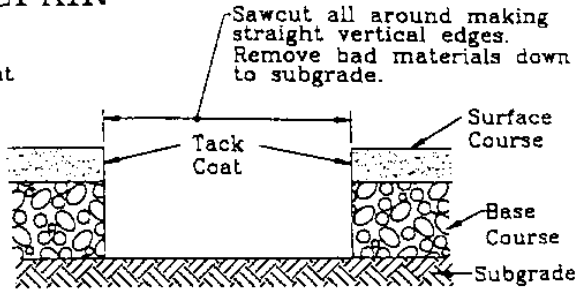


Step I: Locate and mark distress area.



Step III:

(1) Place base course material and compact to required density.
(2) Apply prime coat to new base course.
(3) Place new hot-mix asphalt surface course in layers not to exceed 76 mm (3"). Compact and level to specified grade and density.
(4) Compact with vibratory plate compactor for small patches. Use roller compactor for large patches.



Step II: After bad material is removed, recompact subgrade and apply tack coat to vertical faces of surface course.

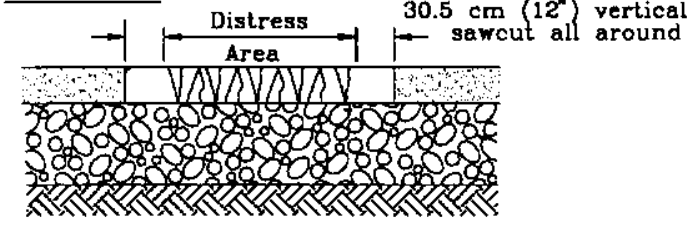
Note: Full base course removal may not be necessary depending on the severity of distress and quality of existing material. Check to make to sure the material is not completely bad.

Method 2:

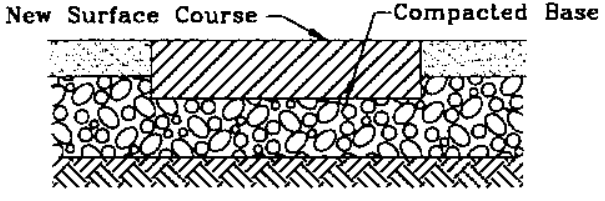
Same as Method 1, but use full-depth asphalt instead of the aggregate base material. Replace the base course material with asphalt mix base or asphalt binder course. Place and compact the full-depth asphalt base [102 mm (4") max. lifts] approx. 51 mm (2"-3") below the pavement surface course. No prime is needed for hot-mix asphalt placed directly over subgrade.

PARTIAL–DEPTH REPAIR
(Figure II)

Method 2:



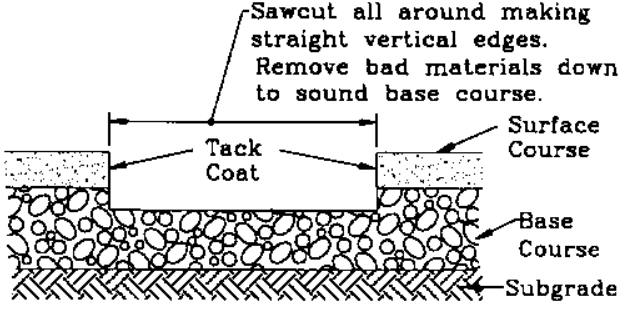
Step I: Locate and mark distress area.



Step III:

(1) Place new Hot–mix asphalt surface course 76 mm (3") max. lifts. Compact and level to specified grade and density.

(2) Compact with vibratory plate compactor for small patches. Roller compactor for large patches.

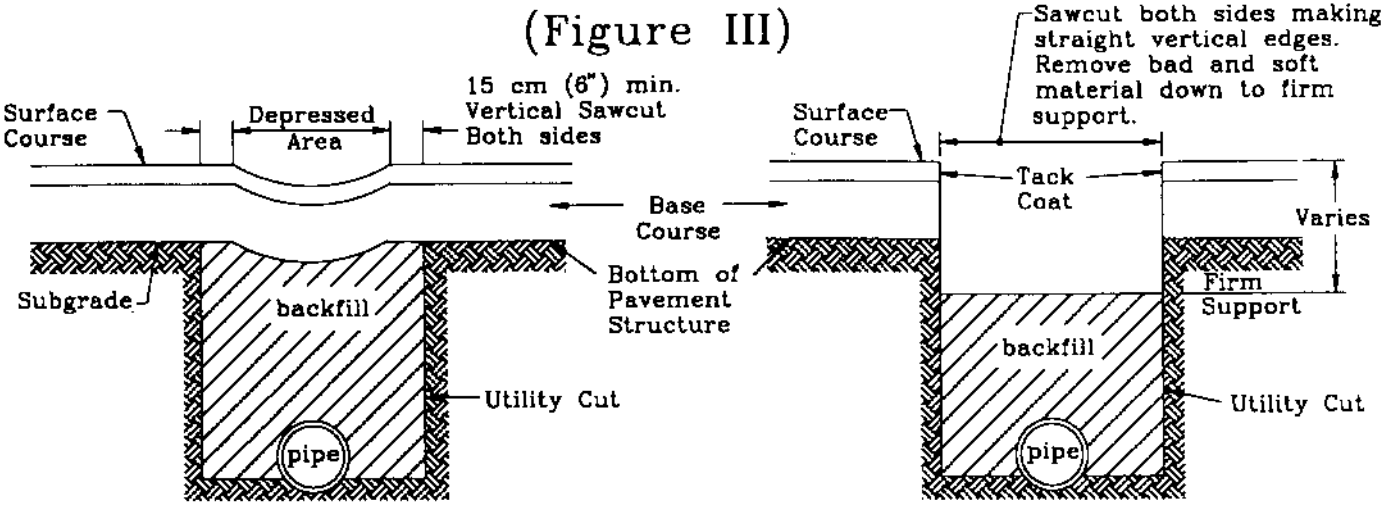


Step II:

(1) Sawcut and remove bad material down to sound base course.

(2) Recompact base to required density. Apply tack coat to vertical faces and base for small patches. Prime coat base for large patches.

REPAIR TO UTILITY CUT
(Figure III)



Condition: A depression in a pavement surface that develops from a cut for utility installation.

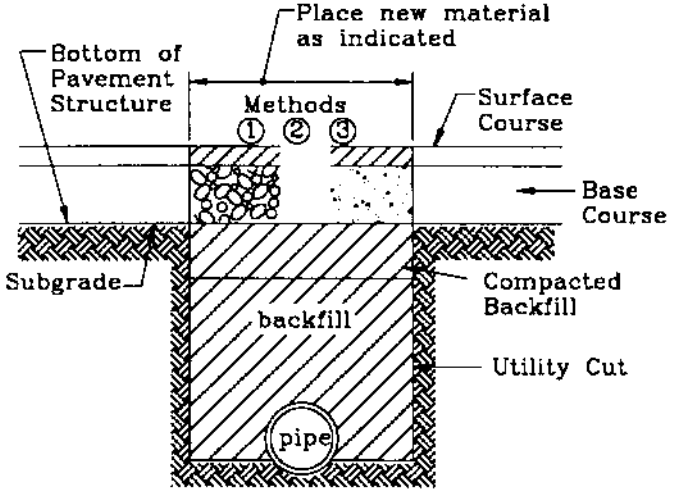
Step I: Locate and mark 15 cm (6") min. from edges of the depressed area.

Step II:

(1) Sawcut both sides – Remove asphalt and soft material down to firm support. (If necessary, down to the pipe). Remove pavement in a manner as not to tear, bulge and displace adjacent pavement.

(2) If firm support is down to the base course, backfill with material as indicated in Partial–Depth Patching, Figure II, page 10.

REPAIR TO UTILITY CUT
(Figure III Cont'd)



Step III:

(1) Backfill utility cut with well-compacted layer of backfill material meeting specified density to the bottom of the pavement structure. Max. lifts 30.5 cm (12"). Note: Flowable fill can be used as backfill. This material is a sand-cement mix when set-up it can be dug with a backhoe.

(2) Place new material from the bottom of the pavement structure as follows:

- Methods ① & ② : Same as indicated in Full-Depth Patching. Figure I, Page 9.

- Method ③ : Same as Method ② above but use portland cement concrete (ready-mix or quick-set) instead of the asphalt base course. Allow concrete to cure 7 days min. and for quick-set, 2-3 hours. PCC compressive strength 210 kg/sq.cm (3,000 psi) minimum.

(3) Place the concrete material 51 mm (2") below the pavement surface, apply tack coat, and place new asphalt surface course.

FILLING DEPRESSION AND RUTS
(Figure IV)

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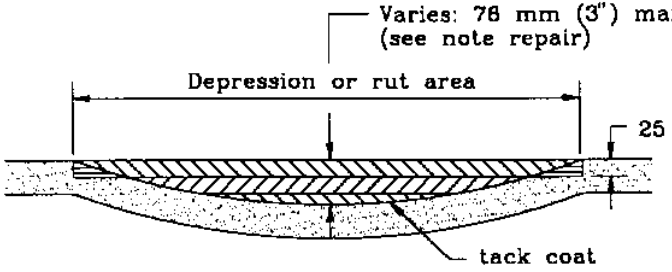

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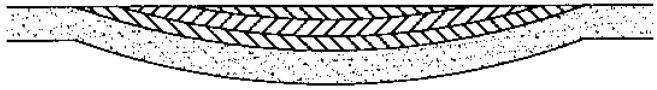


Note: If depression/or rut area is accompanied by medium to high severity cracks (alligator), full or partial depth repair should apply. See (Figures I & II), pages 9 and 10.

Repair:

(1) Mill 25 mm (1") deep around edges of distress area.*

(2) Apply tack coat and place new hot-mix asphalt surface course.
If depression is 76 to 152 mm (3" to 6") deep, place mix in layers (76 mm (3") max. lifts. For depression 13 mm (1/2") or less, leveling course shall be used with sand mix or smaller aggregate 6.5 & 9.5 mm (1/4" & 3/8" size).

(3) Compact and level to specified grade and density.

(4) Seal the edges of the new patch with the appropriate joint sealant material.

* Milling not required if repair is followed by an overlay or surface treatment.

PHOTO 1

Sawcut around area to be patched, leaving vertical edges and square corners.

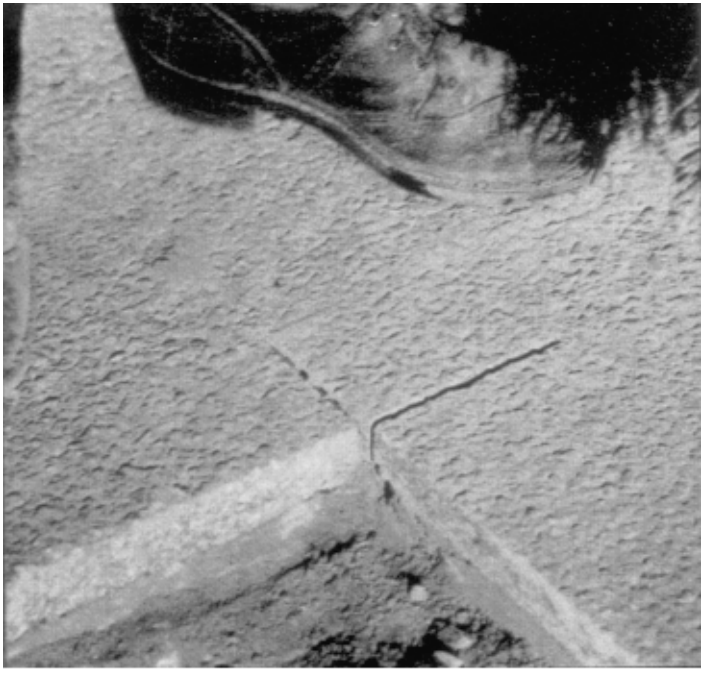


PHOTO 2

Sawcut around area to be patched, leaving vertical edges and square corners.

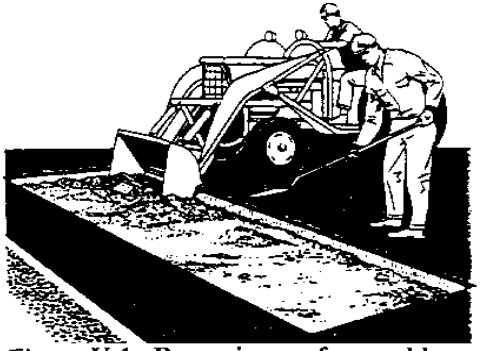


Figure V-1. Removing surface and base

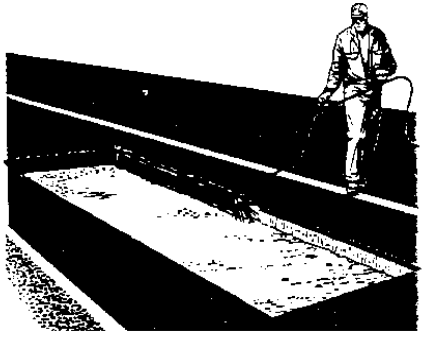


Figure V-2. Applying tack coat to vertical face

Figure V-3. Backfilling hole with plant-mix

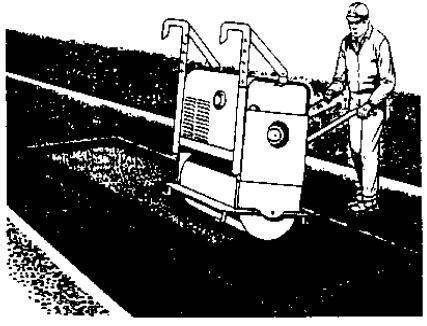


Figure V-4. Compacting the asphalt hot-mix

3. Mill Edges of Distress Area. For filling depressions and ruts in airfield pavements, mill edges of distress area 25 mm (1 in.) minimum depth. For filling depressions and ruts in roads and parking areas, it is still recommended to mill the edges, but successful local practice of not milling the edges is an acceptable alternative.

4. Jackhammer and Remove Defective Material. Use an asphalt blade bit for the jackhammer. Always jackhammer from the middle to the edge and do not rock the hammer near the edge, as this destroys the vertical edges. If you do not have a saw available cut the perimeter of the patch with the jackhammer, however, this is not the recommended method because it leaves rough edges. Again, make sure the cut is as vertical as possible. After jack hammering, remove and haul away the material. If surface and base is removed by a bachoe, care should be taken to ensure the sawcut vertical edges are not damage from the removal operations.

5. Remove. Replace and Compact the Base. When making a full depth patch, check the base material. Remove the bad base material until you reach good, dry, sound material if the cause of the distress is the base. Replace it with a good quality, well-graded base material. Place new material in 51 to 76 mm (4 to 6 inch) lifts, compacting each lift to the required density. Base material will be disturbed when you remove the defective pavement. So, always recompact base even if no base problem is evident **(Figures V-1 through 4)** see page 15.

6. Apply Tack Coat, (and Prime Coat if Used). Although not required, you may spray a prime coat on the base material. The prime should penetrate into the base material. Recommended materials are RC-70, MC-30, MC-70, or SC-70 cutback, an SS-1, 1h, or CSS-1, 1h emulsion. The application rate is 0.45 to 1.25 liters/m^2 (0.10 to 0.25 gal/yd^2). Be sure not to apply too heavy a coat or bleeding may occur. Also, be aware that the prime coat will need time to cure. Prime coat penetrates the base material within 2 to 3 hours and fully cures in up to 48 hours. **Always** use a thin tack coat on the edges of the patch, and on the old pavement if the patch is

on an overlay with good pavement as the bottom of the patch. This provides for a good bond between the new material and on old pavement that is being overlayed. The edges must be clean, dry and free of any dust to make sure the tack bonds to the edges. Again, use a cutback, grades RC-70, 250 or an emulsion, grades RS, MS-1, SS-1, 1 h, CSS-1, 1h, or an asphalt cement, grades AC-2.5, 5, 10, AR-1000, 2000, or 4000. The application rate is 0.25 to 0.45 liters/m^2 (0.05 to 0.10 gal/yd^2). Use a spray wand to apply the tack **(PHOTO 3)** see page 19. If a wand is not available, use a stiff brush. Be sure not to apply too much tack (too little is better than too much), again to prevent any bleeding. **Note: Beware in some states and localities, the use of cutback asphalt is prohibited or curtailed by air pollution regulations. In these areas, asphalt cement or emulsified asphalt should be used.**

6. <u>Place the Patch Material</u>. Always use a good quality, hot-asphalt plant mix material. Place and compact material in 51 to 76 mm (2 to 3 inch) lifts. It is leveled on top and overfilled enough to allow for COMPACTION (about 40% depending on the mix, i.e. 76 mm (3") compacted = 108 mm (4-1/4") uncompacted) **(PHOTO 4**) see page 19. Avoid overworking the material with a lute, shovel, or rake, especially at the surface, as this causes segregation of the mix.

7. <u>Compact the Patch Area</u>. Compact the mix using an appropriate method after filling to the proper level. The type of compactor will depend on the size of the patch. For very small areas or areas unable to be reached with large equipment, use a hand tamper. For larger areas, use a vibratory plate tamper, or a steel wheel

roller **(PHOTOS 5, 6)** see page 20. Always ensure it is the proper size for the job and will give you the required COMPACTION. Always compact the edges of the patch first, then (in the direction of traffic) continue over the rest of the patch, overlapping the previous lane by about 6 inches **(PHOTO 7)** see page 21. When the patch is completely compacted, it should be about 3 mm (1/8") above the existing surface **(PHOTO 8)** see page 21.

8. Seal the Patch. The last thing to do after finishing the patch is to seal the edges with an appropriate joint sealant material **(PHOTO 9)** see page 22. This will give added protection against water infiltration. Do not make this edge seal too wide; about 51 mm (2 inches) is sufficient. Any wider is a waste of material and may be unsightly.

9. Problem Areas. The biggest problem area is compaction of both the base and patch material. Thin lifts, less than 76 mm (3 in.) will work best for both. Too much tack or prime can also be a problem. If using a wand, test it on another area first to insure that you have the proper settings and spray nozzle. Do not hold it in one place any longer than required to get the proper coating.

PHOTO 3

Applying Tack Coat to vertical edges in the patch areas

PHOTO 4

Overfill patch area so final compaction will bring it up to existing grade

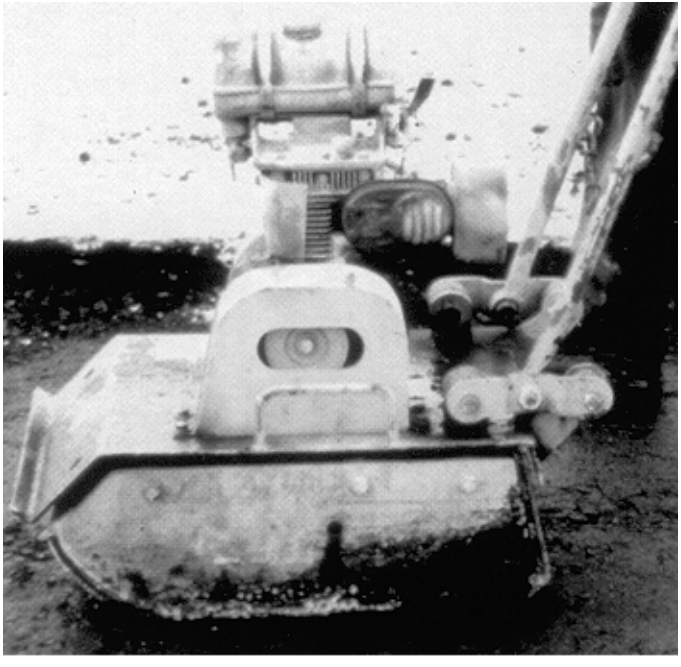


PHOTO 5

A vibratory plate tamper is used on small patches

PHOTO 6

A steel wheeled roller of the correct weight is used on large patches

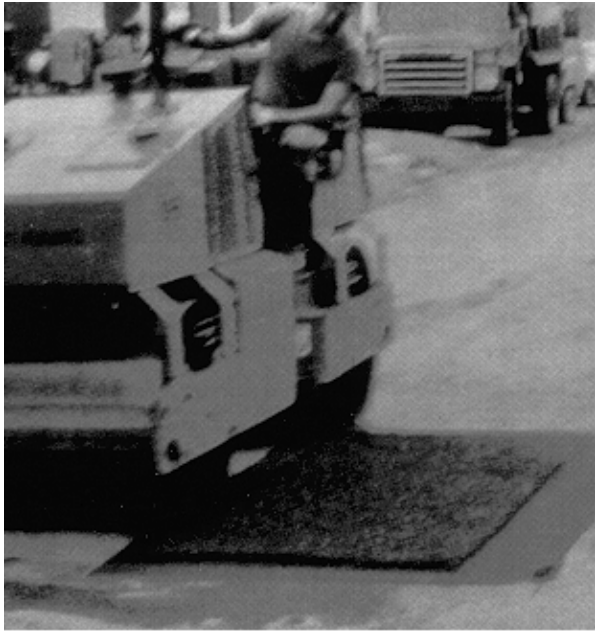


PHOTO 7

Compact the edges of the patch first

PHOTO 8

Finished patch should be slightly higher than the surrounding pavement

PHOTO 9

Seal edges of the patch after compaction

PHOTO 10

Fog coat applied by a calibrated liquid asphalt distributor

SPRAYED ASPHALT SURFACE TREATMENTS PROCEDURES

PRIME COAT

A prime coat is an application of low viscosity cutback or emulsified asphalt to a granular base course in preparation for a subsequent asphalt course. The purpose of the prime coat is to perform several functions:

1. To coat and bond loose mineral particles on the surface of the base.
2. To harden or toughen the surface, thus prevent raveling of the base during construction.
3. To waterproof the surface of the base.
4. To plug and reduce capillary voids.
5. To provide adhesion between the base and the asphalt course.

Note: **Although prime coat is considered an asphalt surface treatment, it should only be used for its intended purpose and not as an end product surface treatment such as fog or slurry seals. After priming, always follow by a succeeding layer of pavement** .

Materials, Rates of Application and Temperature

Cutback asphalts normally used for priming are SC-70; MC-30, 70, 250; and RC-70. However , MC-250 is sometimes used on loosely-bonded, open textured surfaces. Environmental concerns due to the evaporation of the petroleum solvents in cutback asphalts, its use is prohibited or curtailed in some states. The recommended alternative is to use emulsified asphalts, which use emulsifying agents and water in lieu of the petroleum

solvents. Emulsified asphalts used for priming are SS-1, SS-1h and CSS-1, CSS-1h, anionic and cationic types respectively. The ideal rate of application (amount absorbed by the surface in a 24 hour period) is between 0.90 and 2.25 liters/m^2 (0.20 and 0.50 gal/yd^2). Temperatures for priming should be above 10^0 C (50^0 F) in the shade.

STEPS

1. Prepare the Surface. Make sure the surface is free of all loose material, such as dirt, clay, dust, or any other undesired material. Use a light brooming to remove the undesirable material. If the base is excessively dry, sprinkle with a light application of water.

2. Apply the Prime. Apply the prime by a distributor if the area is large enough. If not, use a hand spray wand. The application rate should be as recommended in this section. Ensure the entire area is coated.

3. Allow Prime to Cure. Allow prime coat to cure for at least 24 hours, ideally 48 hours. If there is excess prime, blot with fine sand. Maintain primed surface against damage until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and repriming deficient areas.

4. Problem Areas. The biggest problem is overpriming. Always test the application rate to ensure you have the proper amount. Also, be sure the distributor spray bar nozzles are at the proper angle and height, are of the proper and uniform size, and are not plugged. This applies to the spray wand as well. **(Figures VI & VII)**, see pages 27 and 28.

TACK COAT

A tack coat is a very light spray application of diluted asphalt emulsion. This is applied to an existing pavement surface before it is overlaid with an asphalt concrete. The tack provides a bond between a surface being paved and the new course.

Note: Although tack coat is considered an asphalt surface treatment, it should only be used for its intended purposes and not as an end product surface treatment such as fog or slurry seals. After tacking, always follow by a succeeding layer of pavement.

Materials, Rates of Application and Temperature

The more common emulsion types for tack coats are diluted SS-1, SS-1h, CSS-1, CSS-1h and RS-1, CRS-1. This materials perform best when diluted with equal parts of water and applied at the rate 0.23 to 0.68 liters/m^2 (0.05 to 0.15 gal/yd^2). No more tack coat should be applied to an area than can be covered by the same day's operations. For best results, the surface temperature should be above 27^0 C (80^0 F), and there is no threat of rain.

Anoinic emulsions SS-1 provides better adhesion to basic aggrgates such as limestone, while cationic emulsions CSS-1 are better with acidic aggregates. In warmer climates, consider the use of SS-1h and CSS-1h with harder base and lower penetration.

STEPS

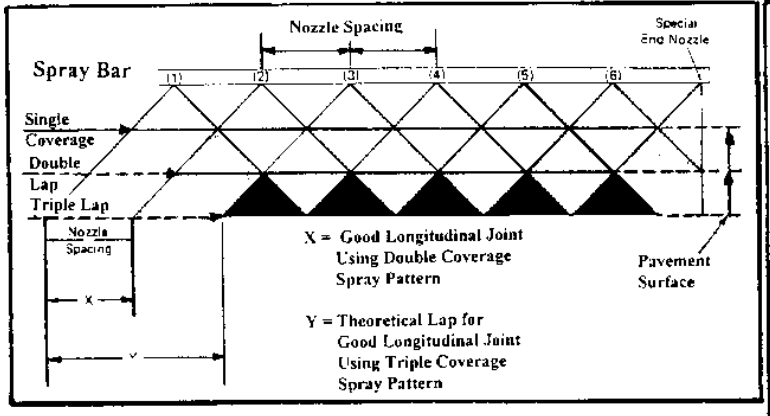
1. <u>Prepare the Surface</u>. The surface must be clean, dry, and free of dust, loose dirt, and other objectionable debris. Clean the surface around and in the patch area with brooms, air, and water.

2. <u>Apply the Tack Coat</u>. Apply the tack coat with a distributor for large areas and use a wand for patches and hard to reach areas. The rate of application should be as recommended above. Ensure the tack is applied in an even, uniform coat over the entire area. No more tack coat should be applied to an area than can be covered by the same day's operation. Remember that too little is better than too much.

3. <u>Allow Tack Coat to Cure</u>. For hot and dry conditions, allow an hour for the emulsion to break (water has evaporated) and a uniform coating of asphalt is left on the surface. For cool and humid conditions, allow 3 hours or longer. Ideally and if the circumstances permit, a cure time of 12 to 24 hours is preferable. The curing period can often be reduced by rolling with a pneumatic-tired roller. Maintain and protect treated surface against damage until succeeding layer of pavement is placed.

4. <u>Problem Areas</u>. Make sure to use the proper application rate and do not over tack, as this causes bleeding and slippage. Always test the application rate to ensure you have the proper amount. Also, be sure the distributor spray bar nozzles are at the proper angle and height, are of the proper and uniform size, and are not plugged. This applies to the spray wand as well. **(Figure VI and VII)**, see pages 27 & 28.

Relationship Of Spray Bar Height To Coverage Pattern



Note: The right setting of the spray-bar height and angle are the key to uniform application of emulsion on the pavement. This should be adjusted to give exactly a double or triple lap (see Figure VII). The nozzle setting must be adjusted so that the fan from each does not interfere with the next. Angle of setting are normally 15-45 degrees depending on the equipment manufactures recommendation.

Note: Single coverage is shown only for clarity and simplication; triple lap coverage is the most popular pattern.

Effects of Improper Spray Bar Height

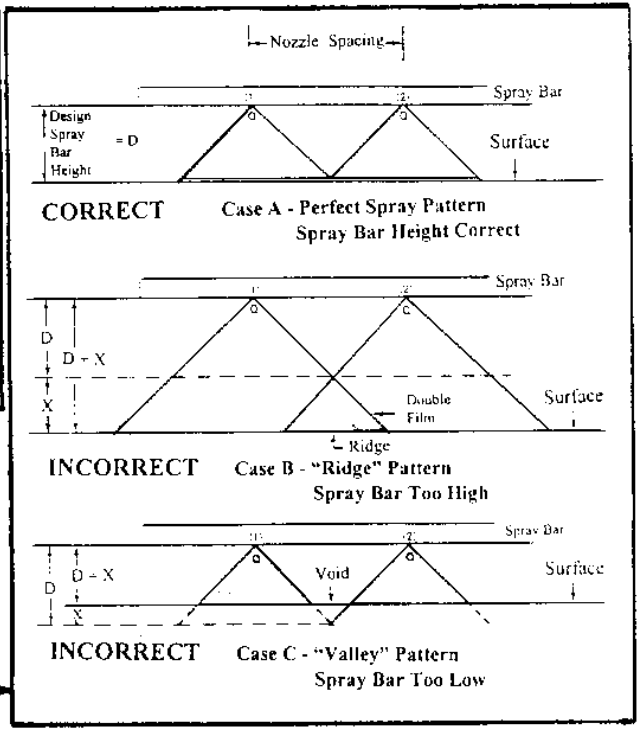
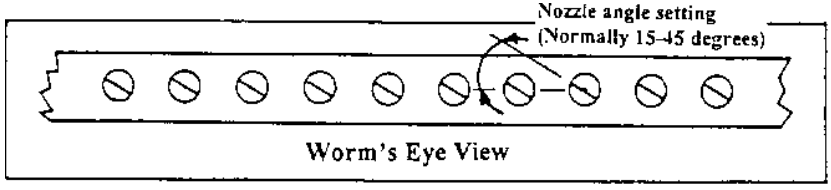
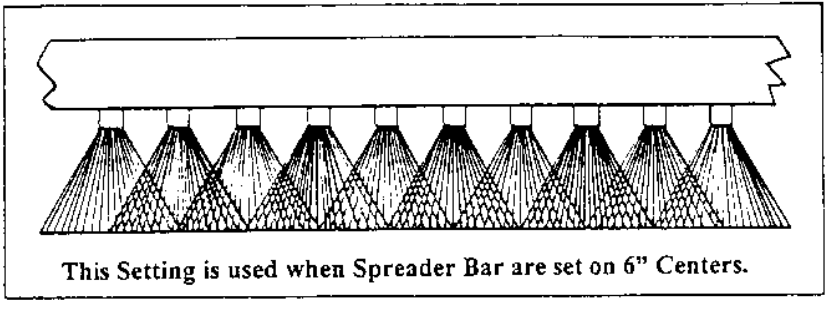


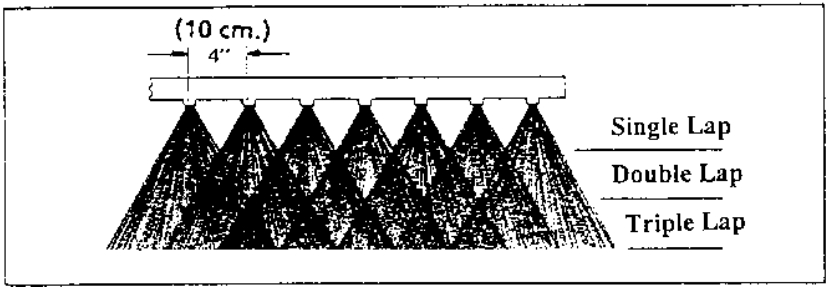
Figure VI



— Properly Adjusted Tips



— View of Nozzle Setting Giving a Perfect Double Lap



— Perfect Triple Lap

Figure VII

FOG SEAL

A fog seal is a spray application to an existing asphalt concrete pavement surface of a slow-setting asphalt emulsion diluted with water. It can be diluted up to one part emulsion to five parts water, but in most cases a one to one dilution is used. Fog seal is used to renew old asphalt concrete pavement surfaces that have become dry and embrittled with age, to seal small cracks and surface voids and to inhibit raveling. This corrective action will prolong pavement life and may delay the time when major maintenance or rehabilitation is needed.

Materials , Rates of Application and Temperature

Grades of asphalt emulsion normally used for this purpose are SS-1, SS-1h, CSS-1, or CSS-1h. The rate of application is normally in the order of 0.45 to 0.70 liters/m^2 (0.1 to 0.15 gal/yd^2) of diluted material. Exact quantities are determined by the surface texture, dryness, and degree of cracking or raveling of the pavement on which the fog seal is sprayed. Similarly to tack coat, for best results, the surface temperature should be above 27^0 C (80^0 F), and there is no threat of rain.

STEPS

1. Prepare the Surface. As with prime and tack coats, thoroughly clean the surface prior to application. Also repair any other distresses before application.

2. Dilute the Material. Follow the dilution rates recommended in this section, and use the one that has worked best in the region. If past data is not available, **use a one to one dilution**. Recommended that only diluted emulsion should be used.

3. Determine Proper Application Rate. Do this by using field test sections and different application rates to see which is the best. The rate will vary according to the amount of material the pavement absorbs. Adjust the rate so that the surface is not slick, unstable, or have excess material on the surface after curing for 12 to 24 hours.

4. Apply the Material. Use a calibrated asphalt distributor for application **(PHOTO 10)** see page 22. The calibration of the distributor is very important. Also, make sure the spray bar nozzles are at the proper angle and height, are of the proper and uniform size, and are not plugged (**Figures VI and VII**) see pages 27 & 28. Apply in increments of 1/3 to 3/4 of the total amount over the entire area. This avoids getting a very slick surface.

5. Cure. Allow the fog seal to fully cure before allowing any traffic on the pavement. For hot and dry conditions, allow an hour for the emulsion to break (water has evaporated) and a uniform coating of asphalt is left on the surface. For cool and humid conditions, allow 3 hours or longer. Ideally and if the circumstances permit, a cure time of 12 to 24 hours is preferable. The curing period can often be reduced by rolling with a pneumatic-tired roller.

6. Problem Areas. The distributor calibration and the spray bar are possible problems on any applications, so make sure the distributor is calibrated properly, adjusted, and clean. Be sure to do test applications to determine the proper application and dilution rate. Make sure that only diluted emulsion is used. Failure to dilute emulsion material can be a source of trouble. Generally, fog seals **are not allowed on airfields** because of the tendency to reduce skid resistance. In addition, in cases where cracks have been presealed, emulsion will not penetrate crack seals and may result in "fat spots" of excess asphalt.

NOTE REGARDING REJUVENATORS: Rejuvenators are asphalt based products that claim to rehabilitate asphalt concrete pavements. The rejuvenator penetrates the entire depth of the asphalt concrete layer thereby reestablishing pavement flexibility and prolongs pavement life. Always check with your NAVFAC pavement engineer **before** using commercially advertised rejuvenator products. Use only experienced contractors who have been successful in its application. Over application of rejuvenators may cause bleeding and may structurally weaken the asphalt pavement.

SPRAYED ASPHALT AND AGGREGATE TREATMENT PROCEDURES

Single and Double Bituminous Surface Treatments (also known as Chip Seals)

These are sprayed asphalt applications followed immediately by one or more layers of aggregate. They are used to retard deterioration such as raveling, improve skid resistance, seal small cracks, and waterproof the surface. They are usually used on light traffic roads. **Do not use chip seal on airfield pavements and overrun areas**.

Single Bituminous Surface Treatment (SST)

Materials

The bituminous materials used are:

Cutback RC-250, 800, 3000 (See Note below)	Emulsion RS-1, 2	CRS-1, 2
Asphalt Cement AC-2.5, 5, 10, 20	AR-2000	

NOTE: In some states and localities, the use of cutback asphalt is prohibited or curtailed by air pollution regulations. In these areas, asphalt cement or emulsified asphalt should be used.

The Aggregate Gradation is:

% Passing by Weight, Gradation Designation

Sieve Size	**No. 1**	**No. 2**	**No. 3**
25 mm (1 in.)	100	--	---
19 mm (3/4 in.)	90 - 100	100	---
12.5 mm (1/2 in.)	20 - 55	90 - 100	100
9.5 mm (3/8 in.)	0 - 15	40 - 70	85 - 100
4.75 mm (No. 4)	0 - 5	0 - 15	10 - 30
3 mm (No. 8)	---	0 - 5	0 - 10
1.4 mm (No. 16)	---	---	0 - 5

Apply this treatment when the temperature is 15.6^{0}C (60^{0}F) in the shade and when pavement temperature is 21.1^{0}C (70^{0}F) or higher. Apply surface treatment only when wind velocity will not prevent the uniform application of the cover aggregate.

STEPS

1. <u>Prepare the Area</u>. Before applying a SST, you must repair all failed areas and thoroughly clean the surface.

2. <u>Apply The Binder Material</u>. Apply the binder with an asphalt distributor. The distributor must be properly calibrated and the same precautions taken as for sprayed asphalt treatments. The application rates are as follows:

TYPES:	<u>EMULSIFIED ASPHALT</u>		<u>CUTBACK & ASPHALT CEMENT</u>	
	Bitum. Mat'l	**Aggregate**	**Bitum. Mat'l**	**Aggregate**
Gradation	liters/m^2 (gal/yd^2)*	kg/m^2 (lb./yd^2)	liters/m^2 (gal/yd^2)*	kg/m^2 (lb./yd^2)
1	1.81-2.26 (0.40-0.50)	22-27 (40-50)	1.36-1.81 (0.30-0.40)	19-24 (35-45)
2	1.36-2.04 (0.30-0.45)	14-16 (25-30)	0.91-1.36 (0.20-0.30)	14-19 (25-35)
3	0.91-1.58 (0.20-0.35)	11-14 (20-25)	0.68-1.13 (0.15-0.25)	11-16 (20-30)

APPLICATION TEMPERATURE

1. Emulsified Asphalt within the following ranges:
   RS-1: 21.1 - 60^0 C (70 - 140^0 F)
   RS-2, CRS-1, and CSR-2: 51.7 - 85^0 C (125 -185^0 F)
2. Cutback & Asphalt Cement

As necessary to provide an application viscosity between 0.00004 and 0.00012 square meter per second (40 and 120 centistokes, kinematics or 20 and 60 seconds, Saybolt Furol).

3. Apply the Aggregate. Apply aggregate immediately after binder material. Apply aggregate by tailgate spreaders on dump trucks or self-propelled hopper type spreaders **(PHOTO 11,12)** see page 36. The calibrated spreaders must be clean, dry and free of dust or other objectionable material. Aggregate should be hard, angular and abrasion resistant.

4. Roll the Aggregate. Roll aggregate immediately after application. Use a pneumatic tired roller of an appropriate size for rolling [tire pressures of 4.20 to 6.30 kg/cm^2 (60 to 90 lb/in^2)]. Use a pneumatic tire roller to avoid crushing the aggregate. You can use a steel wheel roller, but remember that the weight is very important. It should be heavy enough to seat the aggregate, but not crush it. The steel wheel also bridges low spots and may not seat the aggregate properly. Continue rolling until all aggregate particles are properly seated.

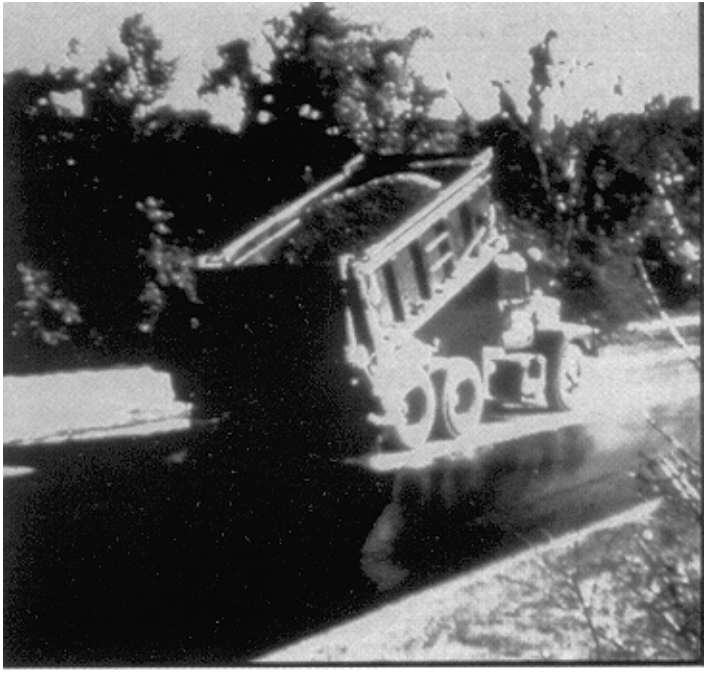


PHOTO 11

Truck mounted tailgate aggregate spreader. (Note the truck is backing up)

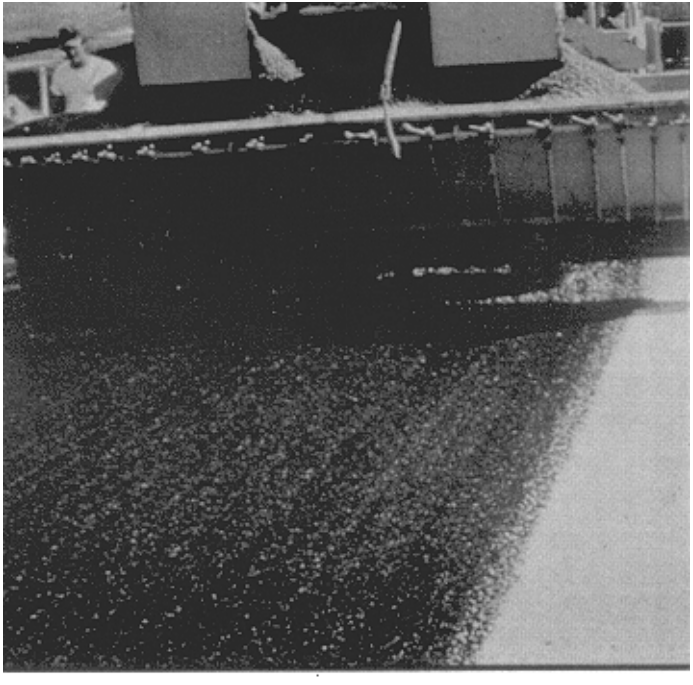


PHOTO 12

Self-propelled hopper aggregate spreader

5. <u>Sweep the Area</u>. Allow the area to cure for at least 24 hours before brooming to remove loose particles (**PHOTO 13**) see page 38. It is best to broom during the coolest parts of the day to avoid dislodging aggregate. Be careful not to use too much pressure on the broom. Use only enough pressure to remove the loose particles.

6. <u>Problem Areas</u>. Always be sure the equipment is properly calibrated. A good way to make sure everything is correct is to use a test section. To make clean straight transverse joints, use building paper where the spreading of the binder and aggregate start and stop. After application, this can be removed leaving a nice straight edge **(PHOTO 14)** see page 38. To prevent a buildup of aggregate on the longitudinal joint, stop the aggregate spread where the asphalt is full thickness **(Figure VIII)** see page 39. This varies according to the spray width of the nozzle but is usually about 6 to 8 inches. On the adjacent pass, apply the aggregate the full width of the spray. After completing the job and opening it to traffic, it is a good idea to limit speeds to no more than 32 KPH (20 MPH) for a few days to ensure the asphalt is fully cured. This prevents dislodging additional aggregate.

PHOTO 13

Rotary power broom used to sweep loose aggregate from pavement

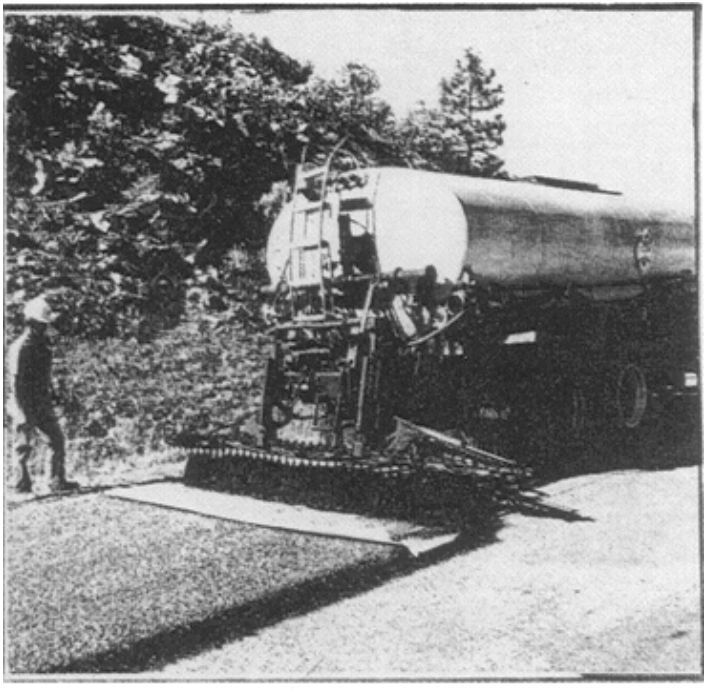


PHOTO 14

Start emulsion application on building paper for clean transverse joints

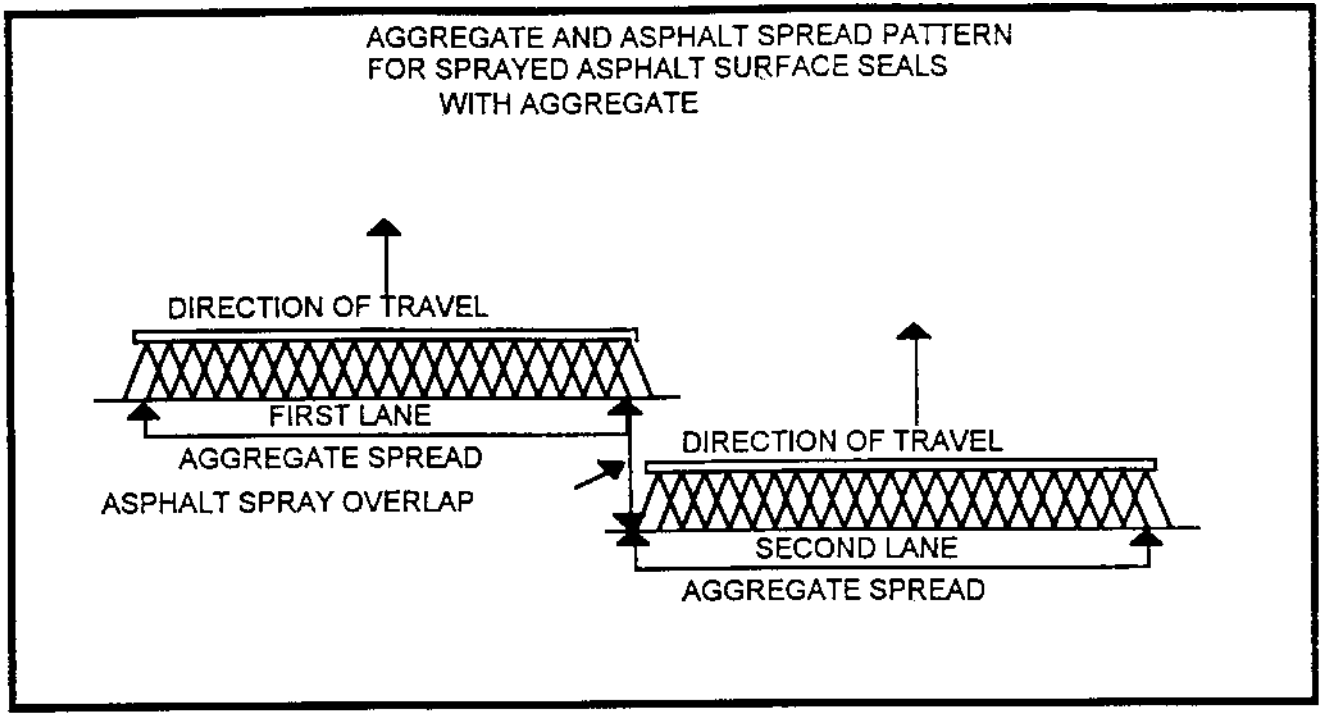

AGGREGATE AND ASPHALT SPREAD PATTERN
FOR SPRAYED ASPHALT SURFACE SEALS
WITH AGGREGATE
DIRECTION OF TRAVEL
FIRST LANE
AGGREGATE SPREAD
ASPHALT SPRAY OVERLAP
DIRECTION OF TRAVEL
SECOND LANE
AGGREGATE SPREAD

Figure VIII

Double Bituminous Surface Treatments (DBST)

These are essentially the same as the SST except two applications of binder and aggregate are used.

Materials

The bituminous materials used are the same as for SST.

The Aggregate Gradation is:

% Passing by Weight, Gradation Designation

Sieve Size		No. 1	No. 2	No. 3	No. 4
25 mm	(1 in.)	100	---	---	---
19 mm	(3/4 in.)	90 - 100	100	---	---
12.5 mm	(1/2 in.)	20 - 55	90 - 100	100	---
9.5 mm	(3/8 in.)	0 - 15	40 - 70	85 - 100	100
4.75 mm	(No. 4)	0 - 5	0 - 15	10 - 30	85 - 100
3 mm	(No. 8)	---	0 - 5	0 - 10	10 - 40
1.4 mm	(No. 16)	---	---	0 - 5	0 - 10
0.3 mm	(No. 50)	---	---	---	0 - 5

STEPS

1. <u>Same as SST</u>.

2. <u>Apply The Binder Material</u>. SAME AS SST except the application rates are as follows:

TYPES:	EMULSIFIED ASPHALT		CUTBACK & ASPHALT CEMENT	
	Bitum. Mat'l	**Aggregate**	**Bitum. Mat'l**	**Aggregate**
Gradation	liters/m^2 (gal/yd^2)	kg/m^2 (lb./yd^2)	liters/m^2 (gal/yd^2)	kg/m^2 (lb./yd^2)
* 1	1.81-2.26 (0.40-0.50)	22-27 (40-50)	1.36-1.81 (0.30-0.40)	19-24 (35-45)
** 2	1.36-2.04 (0.30-0.45)	14-16 (25-30)	0.91-1.36 (0.20-0.30)	14-19 (25-35)
OR				
* 2	1.36-2.04 (0.30-0.45)	14-16 (25-30)	0.91-1.36 (0.20-0.30)	14-19 (25-35)
** 4	0.68-1.13 (0.15-0.25)	8-11 (15-20)	0.68-1.13 (0.15-0.25)	8-14 (15-25)

* First application of surface treatment.
** Second application of surface treatment.
Note: Application Temperature of Binder Material - Same as SST.

3. **Apply the Aggregate. Same as SST.**

4. **Roll the Aggregate. Same as SST.**

5. **Sweep the Area. Same as SST.**

6. **Follow above steps (1 - 5) for second application.**

7. **Problem Areas. Same as SST.**

Sand Seal

This follows the same steps as a SST except uses the following gradations:

% Passing by Weight, Gradation Designation

Sieve Size	No. 1	No. 2	No. 3
12.5 mm (1/2 in.)	100	---	---
9.5 mm (3/8 in.)	85 - 100	100	---
4.75 mm (No. 4)	10 - 30	85 - 100	100
3.0 mm (No. 8)	0 - 10	10 - 40	10 - 40
1.4 mm (No.16)	1 - 5	0 - 10	0 - 10
0.3 mm (No.50)	---	0 - 5	0 - 5

Gradation	Bituminous Material liters/m^2 (gal/yd^2)*	Aggregate kg/m^2 (lb./yd^2)
1	0.90-1.60 (0.20-0.35)	11.30-14.10 (20-25)
2	0.70-1.15 (0.15-0.25)	8.45-11.30 (15-20)
3	0.70-1.15 (0.15-0.25)	5.65-8.45 (10-15)

* If emulsion is used, increase the application rate by 10%.

Apply Sand and Roll

This is a common method used to repair bleeding.

STEPS

1. **<u>Apply Hot Sand</u>**. Heat the sand to above 135^0C (275^0F), then spread using a tailgate or box spreader, or by hand, at the rate of 5.65 - 8.45 kg/m^2 (10 - 15 lb./yd^2).

2. **<u>Roll the Sand</u>.** Immediately after spreading the sand, roll with a pneumatic tired roller.

3. **<u>Sweep Excess Material</u>.** Use an appropriate sweeping method after the area has sufficiently cooled.

ASPHALT SLURRY SEALS

This is a mixture of asphalt emulsion, aggregate, water and mineral filler. Use them to seal and protect worn, weathered, and cracked pavements from the effects of weather and traffic wear. Another use is to reduce skid problems. The limitations to the application of slurry seals are dependent upon the type of use and are listed in the materials section below.

Materials, Application, and Temperature

The type of emulsions used are SS-1, SS-1h, CSS-1, or CSS-1h.

There are three types of aggregate gradations (See page 46) and their allowable usage are as follows:
1. Use Type I for lightly trafficked areas such as parking lots.
2. Use Type II where surfaces contain shallow voids and when a more durable wearing surface than Type I is desired.
3. Use Type III for heavily trafficked areas where crown correction or a high friction surface is desired. **DO NOT USE Type III on airfield pavements.**

SPECIAL REQUIREMENT: A **waiver is required from NAVFAC for the use of Type I and Type II slurry seals on airfield asphalt pavements. Beware that slurry seal is completely prohibited on airfield pavements serving high volume of tactical jets due long closure time and frequent sweeping required to cure and remove loose aggregate.**

The aggregate gradations are as follows:
% Passing by Weight, Gradation Designation

Sieve Size		Type I	Type II	Type III
9.5 mm	(3 /8 in)	---	100-	100
4.75 mm	(No. 4)	100	90 - 100	70 - 90
3.0 mm	(No. 8)	90 - 100	65- 90	45 - 70
1.4 mm	(No.16)	65 - 90	45 - 70	28 - 50
0.55 mm	(No.30)	40 - 60	30 -50	19 - 34
0.32 mm	(No.50)	25 - 42	18 - 30	12 - 25
0.15 mm	(No.100)	15 - 30	10 - 21	7 -18
0.075 mm	(No.200)	10 - 20	5 - 15	7 - 15

Mineral Filler

If used in the slurry, use a Portland cement or hydrated lime. The filler tends to improve the stability of the mix. If stability or segregation problems occur, use mineral filler at 0.4% to 0.5% of the total mix.

Water
Use only potable water. Water is the primary control for workability of the mix.

STEPS

1. **Prepare the Surface**. Remove all loose material from the surface (including any loose or flaking paint), dirt and vegetation. If vegetation was removed from the cracks, apply a crack sterilant (bromacil, diuron, mouron-TCA, or prometon). The manufacturer's recommended application rate and precautions should be followed. Seal cracks greater than 6.52 mm (1/4 in. in width). When sealing, maintain sealant 3.2 to 6.4 mm (1/8 to 1/4 in.) below the surface. After sealing all cracks and the surface is clean, apply a very light tack coat at the rate of 0.25 to 0.45 liters/m^2 (0.05 to 0.10 gal/yd^2) and allow it to cure fully.

2. **Apply the Slurry**. Fog spray water on the surface with the spray bar on the slurry machine immediately before applying the slurry. There should be no standing water after the spray. Adjust the spray for temperature, surface texture, humidity, and dryness of the surface. Apply the slurry with a slurry machine **(PHOTO 15)** see page 48. This is a self-propelled, continuous flow mixing unit. It should be capable of delivering the proper amount of aggregate, water, mineral filler, and emulsion to the mixing unit **(Figure IX)** page 48. The mixing unit is either a single or double pugmill mixer. The mixing unit discharges the material into the spreader box. The spreader box is equipped with flexible squeegees and width adjustment **(PHOTO 16)** see page 49. Other parts of the machine are the spray bar for wetting the pavement and an aggregate pre-wetting device. Many times, a burlap drag is behind the spreader box to improve the joints and overall appearance of the mix.

Apply the slurry no thicker than 3.0 mm (1/8 in.) and usually no more than 6.4 mm (1/4 in.) thick, in one pass. If more than one pass is used, allow the previous layer to fully cure before the second application is applied.

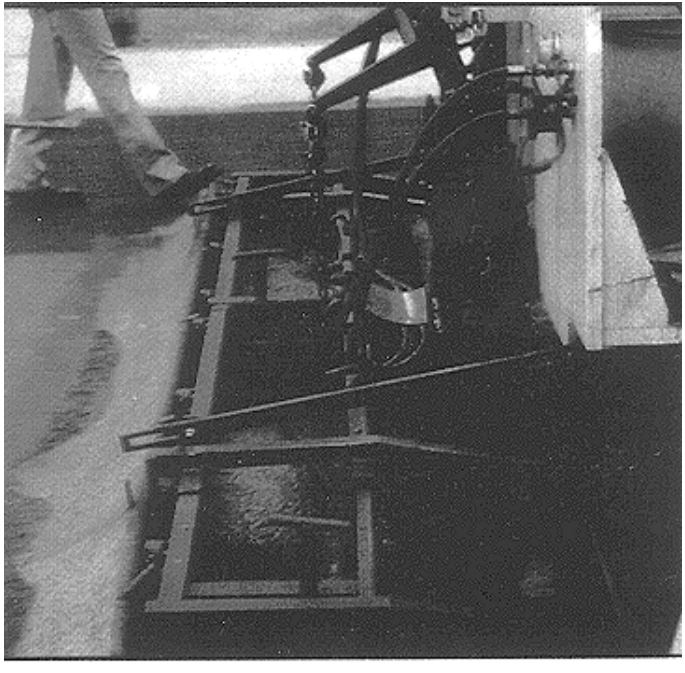


PHOTO 15

Slurry spreading machine
with spray bar

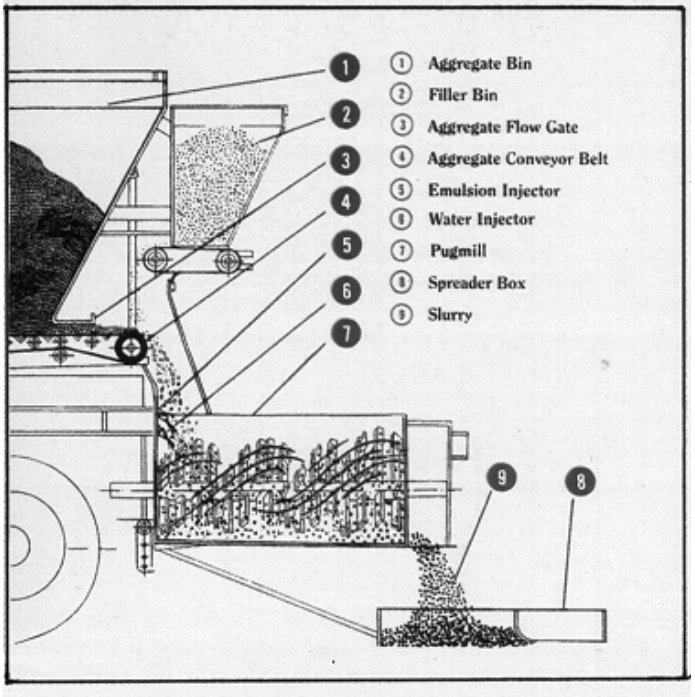
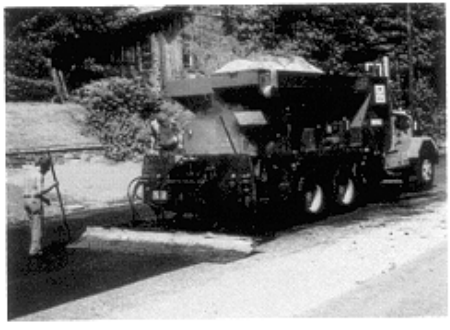


Figure IX
Flow diagram of a typical slurry seal mixer

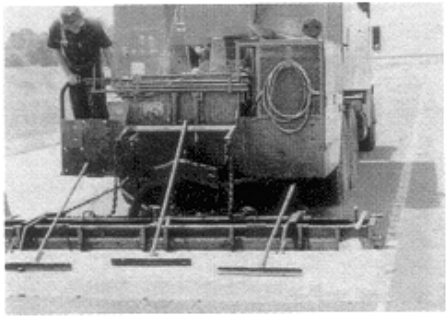
Slurry Seal Material Application

Squeegee Hand Applied

PHOTO 16



Burlap Finished



Squeegee Finished

3. Roll the Slurry. Roll the slurry to reduce the voids, limit surface imperfections, and increase the slurry's resistance to water. Do this when the slurry has cured enough to support the roller without picking up any of the slurry mixture. A five ton pneumatic tire roller with tire pressures of 3.50 kg/cm^2 (50 PSI) is very effective.

4. Cure the Slurry. Cure time is mostly a function of emulsion type and weather conditions. Cationic and "Quick Set" emulsions will break and cure much faster than anionic emulsions. Cool, damp and overcast days will slow cure time. The choice of emulsion may depend upon the need of when to open the treated pavement to traffic. Make sure the slurry is fully cured before opening to traffic.

5. Problem Areas. To ensure proper slurry machine calibration, and you have the correct mix, use a test strip. Don't overwork the slurry when hand applying. This causes the emulsion to break prematurely. If possible, apply the second lane of a job while the edge of the previous pass is still fluid and workable. If not, allow the material to cure enough that the spreader box will not damage the previous pass. Keep the burlap drag clean to prevent buildup of material on the drag, buildup causes streaking and gouging, and replace as needed. Be sure to check on the flexible lining of the spreader box for wear or accumulation of cured slurry.

FUEL-RESISTANT PAVEMENT SEALERS

Fuel-resistant pavement sealers protect asphalt concrete pavements from the effects of fuel spillage thereby extend the life of the pavement areas. Asphalt concrete pavements treated with these sealers allow the use of these areas for maintenance activities.

Materials, Rates of Application, and Temperature

Rubberized coal tar emulsion, rubberized sealant, and nitrile rubber adhesive.

Rates of application vary from 0.54 - 0.82 liters/m^2 (0.12 - 0.18 gal/yd^2) depending upon the specific product. The application rate should follow the manufacturer's recommendation.

Application should occur during the summer when the temperature is warmer than any other time of the year. Temperatures for sealing should be above 10^0 C (50^0 F) in the shade.

STEPS

The steps vary according to the type of sealer and the size of the area to be sealed. The following are general construction recommendations for pavement sealing.

1. **Prepare the Surface**. Repair all failed areas. Seal any cracks greater than 1/4 inch. Thoroughly clean the surface with a mechanical street sweeper or powered broom. New asphalt concrete surfaces should be allowed to cure for several weeks prior to sealing.

2. **Apply the Sealer**. The **use of a mechanical squeegee** to apply the sealer when applicable will provide for a more uniform surface than hand squeegeeing. The application rate can be more accurately controlled by mechanical than by hand application. No matter how the sealer is applied, when a squeegee is used, the minimum rate or thickness is controlled by the maximum sized aggregate particle in the sealer mixture. The squeegee must ride over these particles and the as-placed thickness cannot be less than the diameter of the largest aggregate particles **(PHOTO 17)** see page 53.

The **use of a sprayer** provides the most control over application rates, as the rate is not affected by the size of the aggregate.

3. Apply Sand. Clean, dry sand is added to the sealer to provide a suitable riding surface, i.e., improved skid resistance. The sand will also aid in filling any cracks and normally improves workability of the sealer.

4. Apply Second Coat. A second coat of sealer is required when there are pinholes or voids left in the first coat. These pinholes or voids occur most often when a component of the sealer evaporates as it cures. A second coat also helps correct minor surface defects present in the pavement, such as small cracks and holes.

5. Allow Sealer to Cure. Traffic should not be allowed on the sealed pavement for a minimum of 24 hrs after placement, but in no case before the sealer has achieved an initial set.

Fuel damaged pavement had to be removed and patched before the fuel resistant sealer is applied. The mixed sealer is poured onto the pavement and spread with a squeegee.

PHOTO 17

THIN ASPHALT CONCRETE (AC) OVERLAY

AC overlays may be used to correct both surface deficiencies (weathering, raveling, roughness, slipperiness) and structural deficiencies. Surface deficiencies in asphalt pavements usually are corrected by thin resurfacing, but structural deficiencies require AC overlays designed on factors such as pavement properties and traffic loadings.

TYPES

1. **Thin Overlay**: A thin overlay is a single course of hot-mix asphalt concrete laid over an existing pavement. It usually ranges from 25 mm (1 in.) up to 51 mm (2 in.) thick, using a fine-grained dense mix, 9.5 or 12.5 mm (3/8 in. or 1/2 in.) top size aggregate (**Figure XI)**, see page 69. Generally, the maximum size aggregate for wearing course overlay should not exceed 40% of the designed thickness.

2. **Structural Overlay**. A structural overlay may be single or multiple courses of hot-mix asphalt concrete laid over an existing pavement. The asphalt concrete courses could be a combination of a wearing course and a binder course. Refer to NAVFAC NFGS 02742A "Hot Mix Bituminous Pavement" 31 Mar 96 for guidance. Methods of structural analysis are discussed in DM 21 for both airfields and roads. Nondestructive testing (NDT) layered elastic methods can be used, refer to TM 5-822-13 for roads and TM 827-2 for airfields.

Note: Only thin AC overlay will be discussed in this manual. Structural overlay will not be covered in this manual.

Materials, Applications, and Temperatures

I. A job mix formula for hot-mix asphalt paving should be submitted to the government for approval. The job mix formula should have been prepared within one year of submittal and should indicate physical properties of the mixes as shown by tests made by a commercial laboratory approved by the government, using materials identical to those provided on that project. The design mix should use procedures contained in Chapter II, Marshall Method of Mix Design, of the Asphalt Institute (AI) Manual MS-2.

Job-mix formula shall show the following (See NFGS 02742A for more specific information):

a. Source and proportions, percent by weight, of each ingredient of the mixture;
b. Correct gradation, the percentages passing each size sieve listed in the specifications for the mixtures to be used, for the aggregate and mineral filler from each separate source and from each different size to be used in
the mixture and for the composite mixture;
c. Amount of material passing the No. 200 (75 micrometers) sieve determined by dry sieving;
d. Number of blows of hammer compaction per side of molded specimen;
e. Temperature viscosity relationship of the asphalt content;
f. Stability, flow, percent voids in mineral aggregate, percent air voids unit weight;
g. Asphalt absorption by the aggregate;
h. Effective asphalt content as percent by weight of total mix;

I. Temperature of the mixture immediately upon completion of mixing;
j. Asphalt viscosity grade [and/or penetration range]; and
k. Curves for the wearing course.

II. Asphalt Cement: Consult local States Highway Dept., Engineering Field Dept., or local industry to determine correct penetration grade per ASTM D946, or the correct viscosity grade per ASTM D 3381 to use for your area.

Asphalt Cement		**Max. Mixture Discharge Temp. ^{0}C**	**(^{0}F)**
Penetration Grade	60 - 70	168	335
	85 - 100	162	325
	120 - 150	154	310
Viscosity Grade	AC-5	146	263
	AC-10	157	315
	AC-20	166	330
	AC-30	166	330
	AC-40	171	340
	AR-2000	162	325
	AR-4000	162	325
	AR-8000	162	325

Mix asphalt cement with aggregate of corresponding mixes in the following proportion:

Asphalt Cement Percent by Weight of Total Mix = 5 - 9 for Wearing Course

III. AGGREGATES: Grade and proportion aggregates and filler so that combined mineral aggregate conforms to the specified grading.

a. Course Aggregate: ASTM D 692, except as modified herein. At least 75 percent by weight of aggregate retained on the No. 4 (4.75 mm) sieve shall have two or more fractured faces. Percentage of wear, Los Angeles test, except for slag, shall not exceed 40 in accordance with ASTM C 131. Weight of slag shall not less than 70 pounds per cubic foot (1120 kg per cubic meters). Soundness test is required in accordance with ASTM C 88; after 5 cycles, loss shall not be more than 12 percent when tested with sodium sulfate or 18 percent when tested with magnesium sulfate.

b. Fine Aggregate: ASTM D 1073, except as modified herein. Fine aggregate shall be produce by crushing stone, slag or gravel that meets requirements for wear and soundness specified for course aggregate. Where necessary to obtain the gradation of aggregate blend or workability, natural sand may be used. Quantity of sand to be added shall not exceed 15 percent of the weight of the course and fine aggregate and mineral passing the No. 200 (75 mm) sieve.

c. **Mineral filler** shall be nonplastic material meeting the requirements of ASTM D 242.

The Aggregate Gradation is:

% Passing by Weight, Gradation Designation

Sieve Size		Wearing Surface			
		Airfields **		Roads*	
		[(1/2 in. Max.)	(3/4 in. Max.)]	[(1/2 in. Max.	3/4 in. Max.)]
19.0 mm	(3/4 in.)	---	100	---	100
12.5 mm	(1/2 in.)	100	89±7	100	82-100
9.5 mm	(3 /8 in.)	86±7	82±7	82-100	68-93
4.75 mm	(No. 4)	66±7	66±7	57-88	48-82
3.0 mm	(No. 8)	53±7	53±7	---	---
2.0 mm	(No.10)	---	---	38-74	32-68
1.4 mm	(No.16)	41±7	41±7	---	---
0.55 mm	(No.30)	31±7	31±7	---	---
0.40 mm	(No.40)	---	---	18-46	17-44
0.32 mm	(No.50)	21±6	21±6	---	---
0.19 mm	(No.80)	---	---	11-30	11-28
0.15 mm	(No.100)	13±5	13±5	---	---
0.075 mm	(No.200)	4.5±1.5	4.5±1.5	5-12	5-12

***** For roads, an acceptable alternative is to use the gradation recommended by the local State Highway Department of Transportation for bituminous paving mixture. **The 1/2 in. and 3/4 in. aggregate gradation for airfield are for pavements subjected to aircraft with tire pressures of 100 psi or greater.

IV. COMPOSITION OF MIXTURE:

a. Gradation of mineral aggregate shall be as specified herein. The percentage of bituminous material provided shall be within the limits specified. Mixtures shall have the following physical properties:

Test Property	Values	
Stability Flow	Not less than 1000 pounds (454 kg)	Roads
(0.01 inch)	Not more than 20 nor less than 8]	
Stability Flow	Not less than 1800 pounds (816 kg)	Airfields
(0.01 inch)	Not more than 16 nor less than 8	
Percent Air Voids	Not less than 3 nor more than 5	Wearing course

b. Minimum Percent Voids in Mineral Aggregate (VMA):

USA Standard Sieve Designation	Nominal Maximum Particle Size	Minimum VMA Percent
No. 4 (4.74 mm)	0.187 inch (4.75 mm)	18
3/8 inch (9.5 mm)	0.375 inch (9.50 mm)	16

1/2 inch (12.5 mm)	0.500 inch (12.50 mm)	15
3/4 inch (19.0 mm)	0.750 inch (19.0 mm)	14
1 inch (25.0 mm)	1.000 inch (25.0 mm)	13

c. Index of Retained Strength: ASTM D 1075, 75 or greater. Other areas with lower quality aggregate such as California use 65.

d. Recycle Asphalt Material: The bituminous concrete mix may contain a maximum of 25 percent (by weight of the total aggregate material) reclaimed asphalt pavement (RAP). The mix design shall meet the requirements for the type of bituminous concrete specified. Clearly state the viscosity of the reclaimed asphalt cement, the grade of new asphalt cement, the properties of the recycling agent (if used) and the percentage of each in the mix. Combine the asphalts and recycling agents to achieve viscosity of 2000 ± 400 poises at 60 degrees C 140 degrees F. Finish a new job mix formula for each change in the percentage of RAP material used. **Recycled asphalt material is not allowed to be used as a wearing course for airfield pavements.**

e. Variations From Formula: Variations from the approved job-mix formula shall not exceed the following , and in no case shall the job-mix formula, with tolerances applied, fall outside the general limits fore aggregate gradation and bituminous material specified herein:

Aggregate	Tolerance (Plus or Minus)
1/2 inch and larger (12.5 mm)	8 percent

3/8 and No. 4	(4.5 and 4.75 mm)	7 percent
Nos. 8 and 16	(2.36 and 1.18 mm)	6 percent
Nos. 30 and 50	(600 and 300 micrometers)	5 percent
No. 100	(150 micrometers)	4 percent
No. 200	(75 micrometers)	3 percent
Asphalt Cement		0.3 Airfield and 0.5 Roads
Temperature of Mixture as discharged		20 degrees F (11 degrees C)

V. Mixing: Ensure that mixing plant produces mixture within the job-mix formula tolerances and meets the requirements of ASTM D 995 "Mixing Plants for Hot-Mixed, Hot Laid Bituminous Paving Mixtures". The plant shall be a batch type, continuous mix type or drum-dryer mixer type, and shall have sufficient capacity to handle the new bituminous construction. For guidance on preparation of mineral aggregates an Bituminous Mixture, equipment calibration requirements, testing, etc... See NFGS-02742A, "Hot Mix Bituminous Pavement" 31 Mar 96.

VI. Paving Equipment:

1. Spreading equipment shall be electronically controlled type equipped with hoppers, tamping, or vibrating devices and capable of spreading hot bituminous mixtures without tearing, shoving, or gouging and to produce a finished surface of specified grade and smoothness. Operate spreaders at variable speeds between 5 (25 mm) and 45 (230 mm) feet per minute when laying mixtures.

2. Rolling Equipment shall be self-propelled pneumatic-tired rollers supplemented by three-wheel and tandem steel wheel rollers. The recommended number, type, and weight are steel-tired roller weighing not less than 8 tons, one steel-tired 2-axle or 3-axle tandem or 3-wheel roller weighing not less than 12 tons, and one pneumatic-tired roller. Pneumatic tired-rollers shall be capable of being operated both forward and backward without turning on the mat, and without loosening the surface being rolled. Equip rollers with suitable devices and apparatus to keep the rolling surfaces wet and prevent adherence bituminous material mixture.
For further guidance on paving equipment , see NAVFAC NFSG-02742A "Hot Mix Bituminous Pavement".

VII. PLACEMENT: Begin machine spreading mixture bituminous material along the centerline of areas to be paved on a crowned section or on the high side of areas with one-way slope. Spread the mixture at the range of temperatures specified herein. Place mixture in consecutive adjacent strips having a minimum width 10 feet, except where the edge lanes requires strips less than 10 feet to complete the area. Construct longitudinal joints and edges to true line markings. Establish lines parallel to the centerline of the area to be paved, and place a string lines coinciding with the established lines for spreading. Place mixture as nearly continuous as possible and adjust the speed of placing as needed to permit proper rolling. Shovelers and rakers shall follow the spreading machine. Broadcasting and fanning of mixture over areas being compacted is prohibited.

In areas where the use of machine spreading is impractical, spread mixture by hand . Spread mixtures with rakes in a uniformly loose layer of thickness that, when compacted, will conform to the required grade, thickness, and smoothness. Place each shovelful of mixture by turning the shovel over in a manner that will prevent segregation. Do not place mixture by throwing or broadcasting from a shovel. Do not dump loads any faster than can be properly handled by the shoveler and rakers.

MINIMUM SPREADING TEMPERATURES

Surface Temp ^{0}C (^{0}F) (Note 1)		Wearing Course Thickness, mm (in.)		
		25.0 mm (1 in.)	38.0 mm (1 1/2 in.)	51.0 mm (2 in.)
minus 7 - 0	(20 - 32) (Note 2)	---	---	---
0 - 4	(32 - 40) (Note 2)	---	---	146 (295)
4 - 10	(40 - 50)	---	149 (300)	141 (285)
10 - 16	(50 - 60)	149 (300)	146 (295)	138 (280)
16 - 21	(60 - 70)	143 (290)	141 (285)	135 (275)
21 - 27	(70 - 80)	141 (285)	138 (280)	132 (270)
27 - 32	(80 - 90)	135 (275)	132 (270)	129 (265)
32	(90)	132 (270)	129 (265)	129 (265)

Note 1: Surface on which mix is placed.
Note 2: Increase by 8^{0}C (15^{0}F) when placement is on surface containing frozen moisture. Normally, hot mix paving is not allowed on surface temperatures below 7^{0}C (45^{0}F).

VII. COMPACTION OF MIXTURE: Compact mixture by rolling. Begin rolling as soon as placement mixture will bear rollers. Delays in rolling freshly spread mixture shall not be permitted. Start rolling longitudinally at the extreme high side of the pavement with a one-way slope. Operate rollers so that each trip overlaps the previous adjacent strip by at least a foot. Alternate trips of rollers shall be of slightly different lengths.

Speed of rollers shall be uniform and slow enough to avoid displacement of hot mixture with the drive roll or wheels nearest the direction of travel (**Figure X, A and B),** see page 66**.** Rollers speed should not exceed 3 mph (5 km/hr) for steel-wheeled static or vibratory wheel or 5 mph (8 km/hr) for pneumatic tires rollers. Correct displacement of mixture immediately by use of rakes and fresh mixture. Continue rolling until marks are eliminated and course has a density of at least 97 percent but no more than 100 percent of that attained in a laboratory specimen of the same mixture prepared in accordance with ASTM D 1559. During rolling, keep rollers moist with only enough water to avoid adhesion of mixture to wheels. Provide sufficient rollers for each spreading machine in operation on the job and to handle plant output. Usually two or more are needed on most projects other than small jobs such as driveways. Rolling freshly placed mixture is done in the following order: (1) Transverse joints; (2) Longitudinal joints (when adjoining a previously placed lane); (3) Initial rolling (or breakdown rolling) which compacts the material beyond the compaction imparted by the paver, to obtain practically all the needed density. (4) Secondary rolling (or intermediate rolling) densifies and seals the surface. (5) Finishing rolling removes rollers marks and other blemihes left from previous rolling.

IX. JOINTS: Joints shall present the same texture and smoothness as other portions of the wearing course, except permissible density at the joint may be up to 2 percent less than the specified course density. Carefully make joints between old and new pavement or within new pavements in a manner to ensure a thorough and continuous bond between old and new sections of the course. Vertical contact surfaces of previously constructed that are coated with dust, sand, or other objectionable material shall be painted with a thin uniform coat of emulsion or other approved bituminous material just before placing fresh mixture.

a. Transverse Joints: Roller shall pass over unprotected end of freshly laid mixture only when laying of course is to be discontinued. Except when an approved bulkhead is used, cut back the edge of previously laid course to expose an even, vertical surface for the full thickness of the course. When required, rake fresh mixture against joints, thoroughly tamp with hot tampers, smooth with hot smoothers, and roll. Transverse joints in adjacent lanes shall be offset a minimum of 2 feet.

b. Longitudinal Joints: Space 6 inches apart. Do not allow joints to coincide with joints of existing pavement or previously placed courses. Spreader screed shall over lap previously placed lanes 2 to 3 inches and be of such height to permit COMPACTION to produce a smooth dense joint. With a lute, push back mixture placed on the surface of previous lanes to the joint edge. When joint is honeycombed or irregular, cut back the unsatisfactory section of joint and expose an even vertical surface for the full thickness of the course. When required, rake fresh mixture against joint, thoroughly compact tamp with hot tampers, smooth with hot smoothers, and roll while hot.

X. Sampling and Testing: For specific information, guidance on sampling (Aggregates at Source; Cold Feed Aggregate Sampling; Course and Fine Aggregates; Mineral Filler; and Pavement and Mixture; and Testing (Aggregate tests, Bituminous Mix Tests, Pavement Courses, Density, Thickness, Smoothness, Finished Grades, and Finished Surface Texture of wearing course).

XI. Protection: Do not permit vehicular or aircraft traffic, including heavy equipment, on pavement until surface temperature has cooled to at least 120 degrees F. Measure surface temperature by approved surface thermometers or other satisfactory methods.

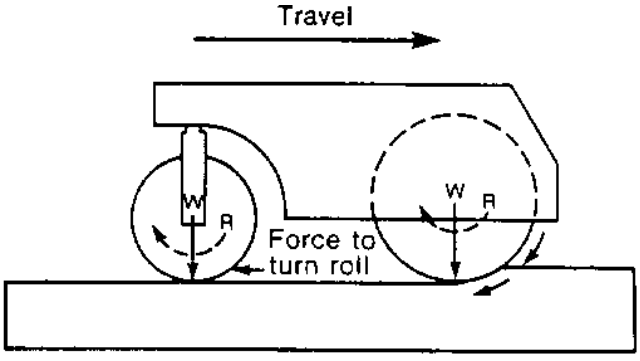


Figure XA -- Proper Direction of Travel

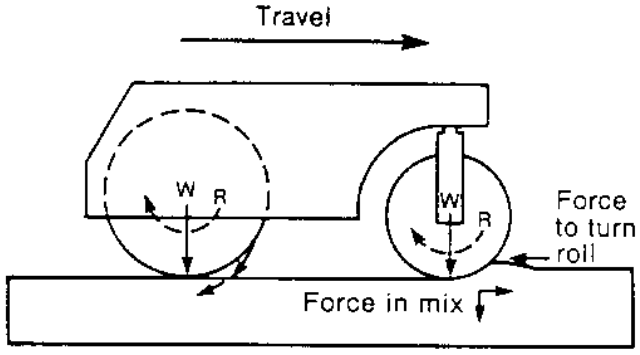


Figure XB -- Improper Direction of Travel

FIGURE X

STEPS

1. **Planing or Cold-Milling**. If required, planing or cold-milling will smooth out rough or distorted surfaces. It will also remove deteriorated wearing surfaces and/or build-up of AC overlays. After milling, any remaining local distresses (alligator crack, potholes, depressions) shall be repaired prior to overlay.

2. **Patch and Seal** . Prior to overlay, local structural distresses (alligator crack, potholes, depressions) should be corrected and cracks greater than 3 mm (1/4 in.) in width should be sealed.

3. **Prepare the Surface**. After patching and sealing operations and prior to overlay, clean the underlying surface of foreign or objectionable matter with power blowers or power brooms, supplemented by hand brooms and other cleaning methods where necessary.

4. **Apply the Tack Coat**. Spray contact surfaces of previously constructed pavement with thin coat of emulsion. Allow tack to cure before ovelayment. (See Sprayed Asphalt Surface Treatment Section “Tack Coat” for rate of application and curing time).

6. **Leveling**. If determined by the engineer to be necessary, the placing of local or general leveling course of minimum thickness will ensure a smooth riding surface and a consistent thickness of AC overlay.

7. Placement and Thickness of AC Courses. The top course of asphalt concrete shall be a minimum of 25 mm (1 in.) and a maximum of 51 mm (2 in.) in compacted thickness. Uncompacted mix loses approximately 40 percent of its height after COMPACTION. Therefore, for a compacted thickness of 25.0 mm (1 in.), the thickness of umcompacted mix should be 42.0 mm (1 2/3 in.). Likewise, for a compacted thickness of 51 mm (2 in.), the thickness of uncompacted mix should be 85.0 mm (3 1/3 in.).

8. Problem Areas. For roads with existing curb and gutters, the build-up of thin overlays may result in road sections with steep cross-slopes, or transverse slopes. And if the overlay is allowed to encroach into the gutter area, the capacity of the roadway section to carry flood waters may be greatly diminished.

If the roadway section is structurally adequate, uniform cold-milling over the entire roadway to the thickness of the proposed overlay will prevent overbuilding. For structurally adequate pavements, the pavement engineer should look at slurry seal or chip seal as alternatives to AC overlay.

If the roadway section is structurally inadequate, milling the section next to the gutter is still preferred prior to placement of the AC overlay.

TYPICAL THIN AC OVERLAY

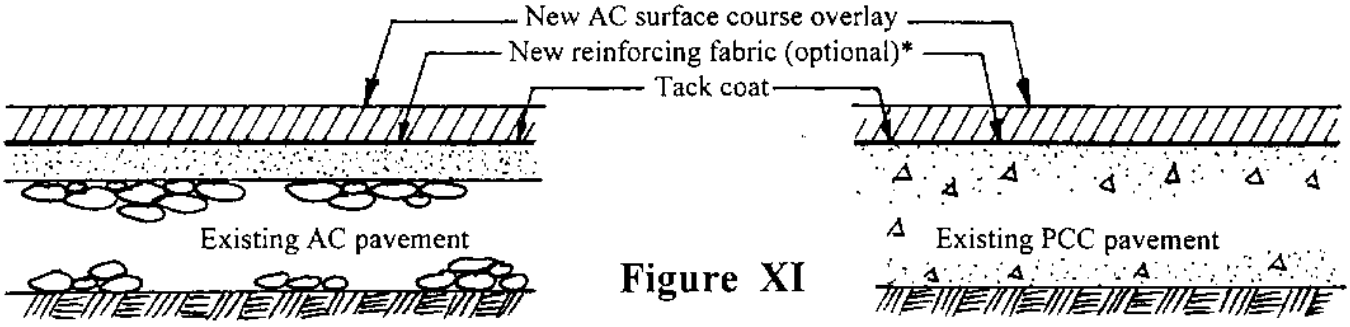


Figure XI

AC Overlay over Asphalt Pavement

AC Overlay over Portland Cement Concrete

Note: *
The use of fabric must be a cost effective application. Evidence shows that the use of fabric over fatigued cracked (alligator), reflection cracking is minimized and longer life is expected. Designer should consult local experiences.

Method:
1. If required, mill entire area (AC only) (PCC selected areas such faulting between slabs). After milling, repair all local distresses.
2. Clean and prepare surface. Use power driven broom to remove dirt, debris and dust.
3. Apply tack coat. If fabric is used, apply tack at the rate indicated and lay the fabric wrinkle free.
4. Place new asphalt surface course overlay.

REINFORCING FABRIC UNDERSEAL IN THIN AC OVERLAYS

The primary use of reinforcing fabric in AC overlays is to reduce reflective cracking. Earlier experience in its use have had mixed results. Best results occurred in areas not subject to the freeze-thaw cycles and thicker overlay. Therefore it should be used in temperate to hot regions only, it must be a cost-effective application, and the minimum thickness overlay shall be 2 inches.

Materials (Similar to AC overlay without reinforcing fabric)

Asphalt Cement Binder (generally should be the same grade of the asphalt cement for the AC overlay. In hot climate areas: use AR-8000 or AC-20, or 60 - 70 for projects with heavy traffic density or high wheel loads. In temperate regions: use AR-4000 for projects with average traffic density.

Reinforcing Fabric Underseal
Provide 100 percent woven or nonwoven polypropylene or polyester fabric, resistant to rot and mildew.
(PHOTO 19) see page 72.

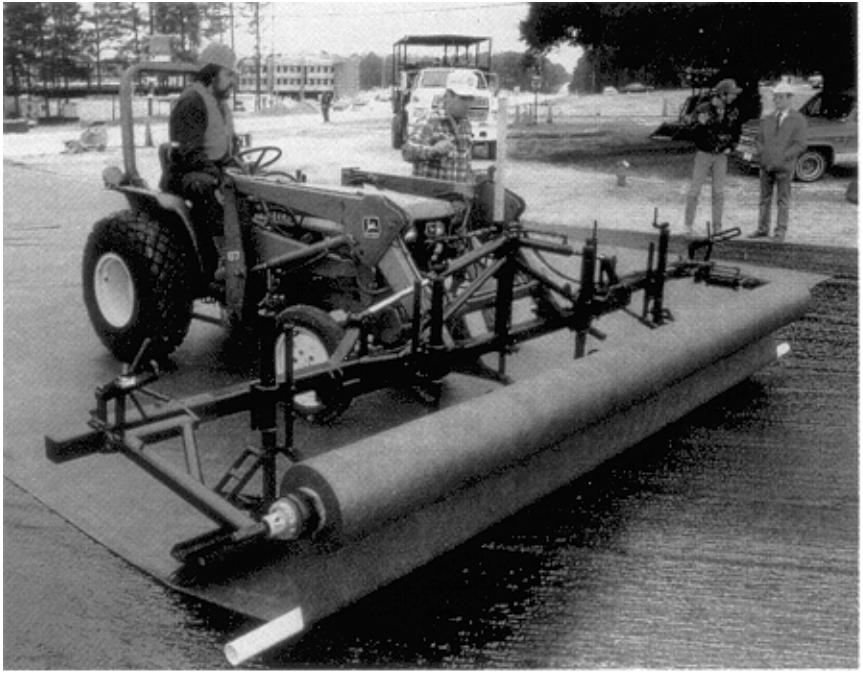
Minimum fabric properties:

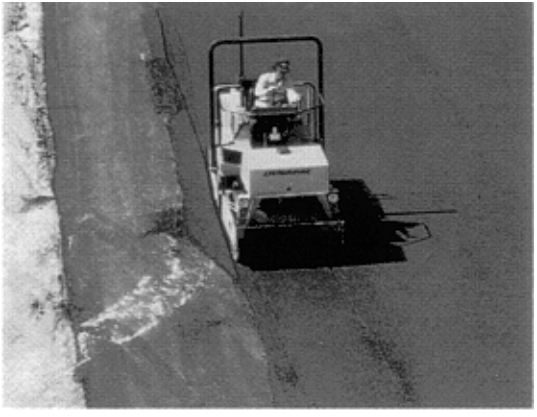
FABRIC PROPERTY	TEST METHOD	FABRIC REQUIREMENTS
Weight	ASTM D 3776	115 G/m^2 (3.4 Oz./yd^2)
Thickness	ASTM D 17777	0.30 mm (12mils)
Grab Tensile Strength	ASTM D 4632	400 N (90 lb)
Grab Tensile Elongation	ASTM D 4632	55 % (55 %)
Asphalt Retention		763 G/m^2 (2.5 Oz./ft^2)
Change in Area from Asphalt		10 % (10 %max)

STEPS

1. through 3. Similar to AC overlay without reinforcing fabric.

4. **Apply the Binder**. Spray area to receive fabric with asphalt cement at rate of 1.0 - 1.31 liters/m^2 (0.22 - 0.29 gal/yd^2). Minimum width of asphalt application shall be fabric width plus 102 mm (4 in.). Minimize time interval between placing asphalt cement and placing fabric so that temperature loss of asphalt cement does not cause loss of adhesion. Keep newly sprayed areas free of traffic and debris until AC overlay is complete.





Above: After application of tack coat, the reinforcing fabric is place on the pavement. *Top right*: Compacting the asphalt overlay. *Bottom right*: Placing the asphalt concrete overlay.

PHOTO 19

5. Place Fabric. **(PHOTO 19)** see page 72. Place fabric free of wrinkles and folds. Place fabric manually on areas where it cannot be mechanically installed. Overlap fabric a minimum of 102 mm (4 in.) at all joints. Do not lap joints with more than two fabric layers. Construct transverse joints so as to prevent fabric disturbance by paver. **DO NOT PLACE MORE FABRIC THEN CAN BE AC OVERLAYED ON THE SAME DAY.**

6. Roll Fabric. Roll fabric in a manner that air bubbles that form under the fabric will be removed. In case binder bleeds through fabric, blot binder with sand. Remove excess sand before placing overlay.

7. Traffic Control. Prohibit vehicles, except handling equipment, from traveling on fabric. Limit equipment speed to 8 kph (5 mph). At intersections and corners, turn equipment gradually to avoid damaging the fabric.

8. Additional Binder. Ensure sufficient binder to bond overlay. If fabric lacks tackiness, apply binder at least 0.9 liter/m^2 (0.02 gal/yd^2) to fabric surface.

9. Place AC Overlay. **Similar to AC overlay without fabric**. Paving operation shall closely follow fabric placement. Do not place more fabric then can be covered with the AC overlay on the same day.

10. Problem Areas. **Similar to AC overlay without fabric**. In addition, improper alignment during fabric placement causes the fabric to wrinkle or fold. In which case, slit the fabric and realign by overlapping the previous material.

End

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